

The Outer Planets – The Jovian and Dwarf/ExtraSolar Planets

Physical Sciences

Broward College

Prepared for AST 1002

Horizons in Astronomy

Objectives

- What are Jovian planets?
- Cross Sections and Atmospheres of the Jovian planets
- Properties of Jupiter, Saturn, Uranus, and Neptune
- Upper Atmospheric Storms and Rings of the Jovian planets
- Moons of the Jovian planets
- Dwarf planets
- ExtraSolar planets

What are Jovian Planets?

- Jovian planets are Jupiter, Saturn, Uranus, and Neptune.
- Jovian Planets are planets with lighter elements, large in size, and orbit further away from the Sun.
- Jovian planets have icy, rocky cores that are under great pressures from large extended atmospheres.
- Jovian planets have many atmospheric layers with some being electrically conductive creating large magnetospheres around the planet. They produce more energy than they receive from the Sun.
- Jovian planets all have many natural satellites.

Cross Sections of Jovian Planets

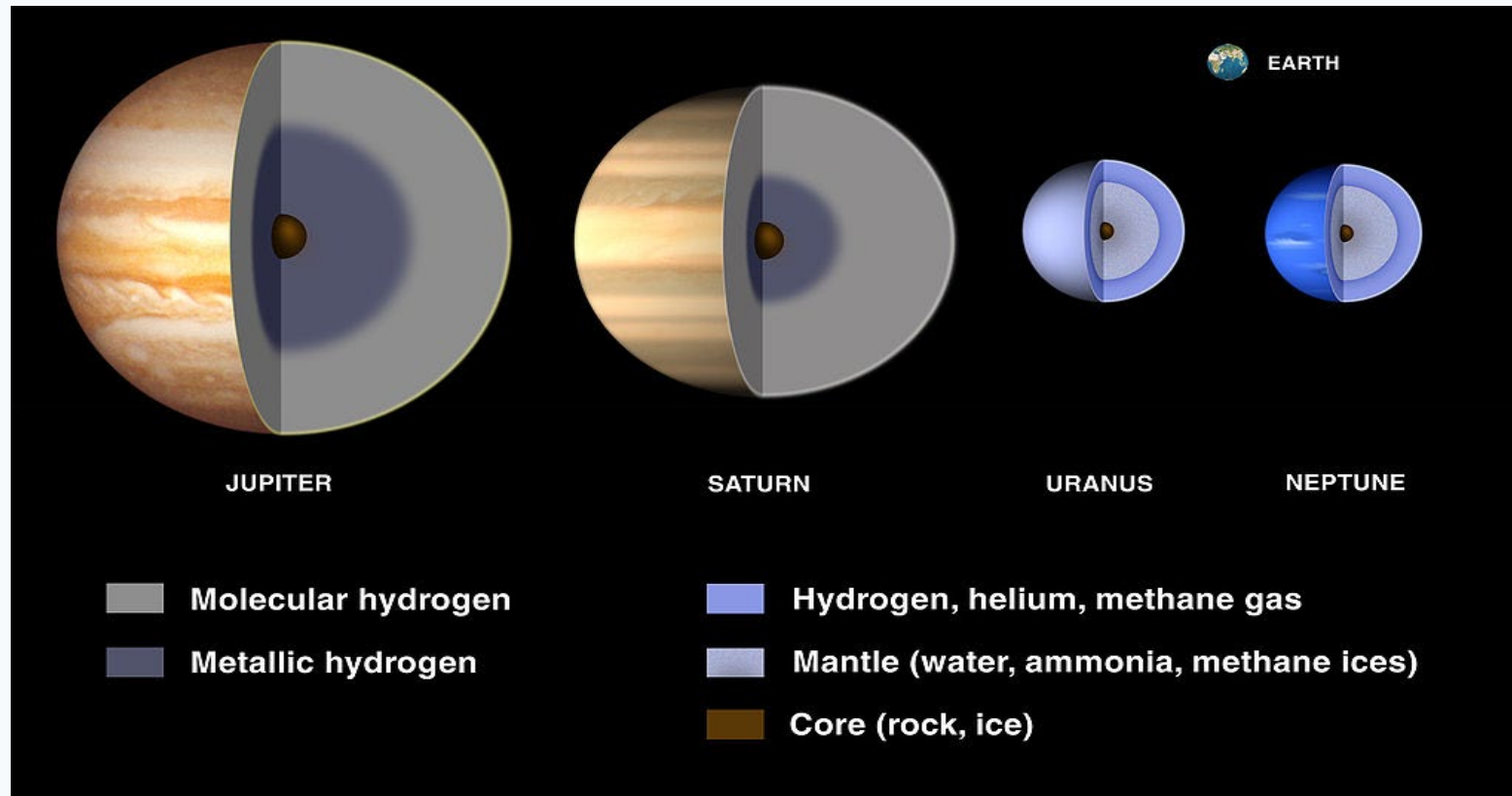


Figure 31. Cross Sections of the Jovian Planets (Wiki)

- Jovian Planets all have solid cores that either carbonaceous or icy.
- Jupiter and Saturn are massive enough to create enough pressure on their hydrogen to make it behave like a conductor thus producing a large amount of heat.
- Uranus and Neptune have been victims of the collisions from outer Solar System objects and have layers of ices that have not settled.

Jovian Magnetospheres

- Jovian planets have magnetospheres that are many times the size of the planet.
- Jupiter and Saturn have magnetospheres that are aligned with axis of rotation while Uranus and Neptune have magnetospheres that are not aligned and are off center from the planet.

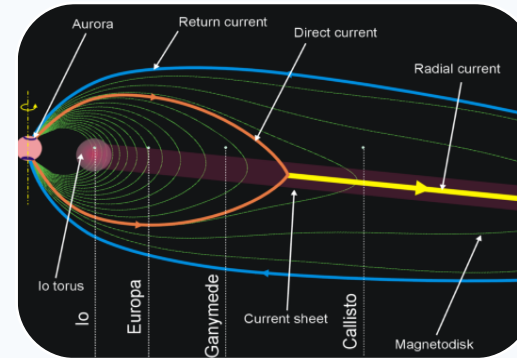


Figure 32. Jupiter's Magnetosphere (Wiki)

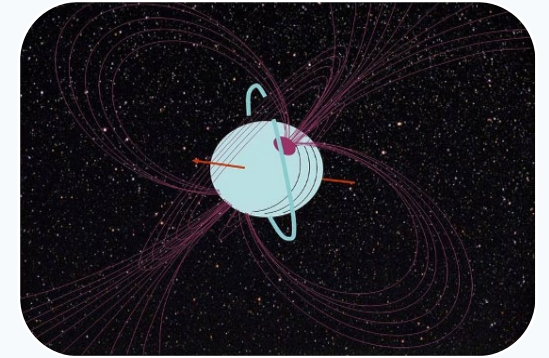


Figure 33 Uranus' Magnetosphere (Wiki)

Jupiter

- Distance: 7.783×10^8 km (7.783 A.U.)
- Albedo: 0.51
- Size (Diameter): 143,800 km ($11.18 D_E$)
- Mass: 1.889×10^{27} kg ($317.83 M_E$)
- Density: 1.34 g/cm^3 ($0.243 \rho_E$)
- Length of Year: 11.87 Earth years
- Length of Day: 0.417 Earth days
- Temperature: 165 K
- Number of Satellites: 67

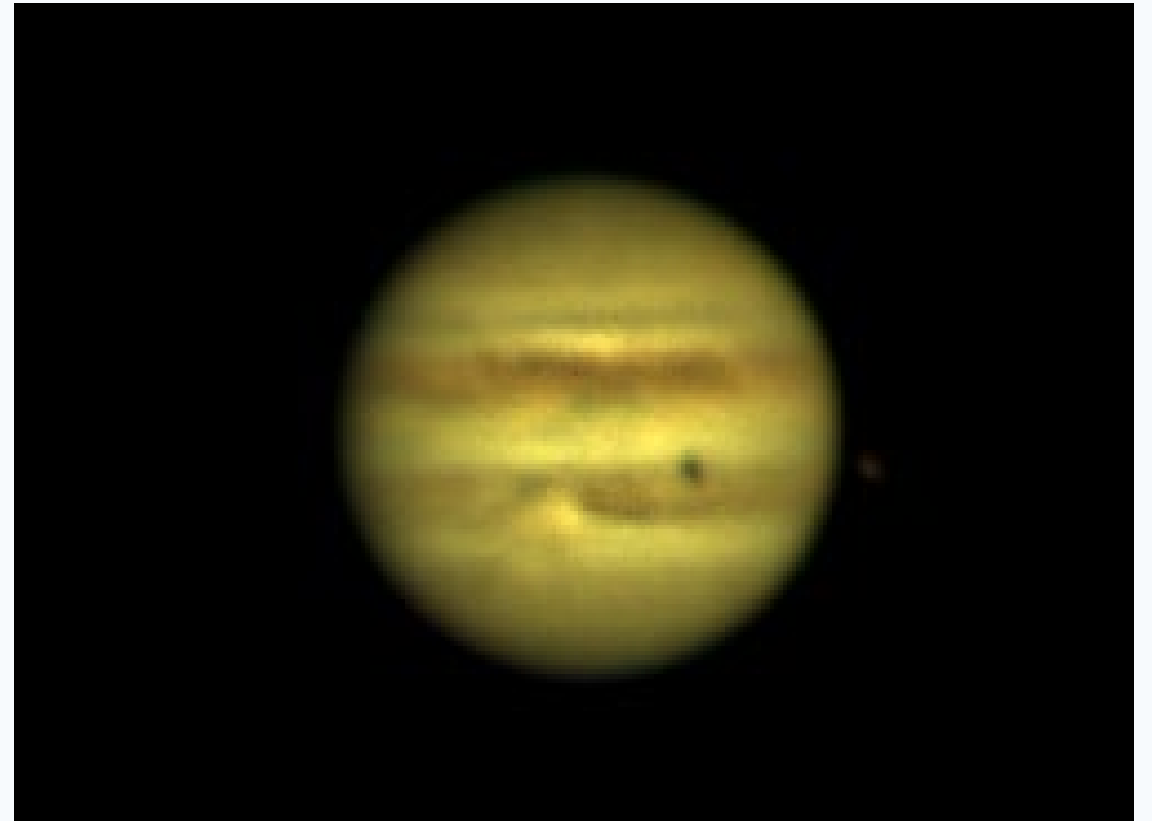


Figure 34. Jupiter (Van Werven, 2015)

Saturn

- Distance: 1.4×10^9 km (9.5 A.U.)
- Albedo: 0.47
- Size (Diameter): 120,536 km ($9 D_E$)
- Mass: 5.68×10^{26} kg ($95.2 M_E$)
- Density: 0.69 g/cm^3 ($0.125 \rho_E$)
- Length of Year: 29.5 Earth years
- Length of Day: 0.446 Earth days
- Temperature: 134 K
- Number of Satellites: 62



Figure 35. Saturn (Van Werven, 2015)

Uranus' Properties

- Distance: 3.0×10^9 km (19.2 A.U.)
- Albedo: 0.51
- Size (Diameter): 57,118 km ($4 D_E$)
- Mass: 8.722×10^{25} kg ($14.6 M_E$)
- Density: 1.29 g/cm^3 ($0.234 \rho_E$)
- Length of Year: 84.0 Earth years
- Length of Day: 0.717 Earth days
- Temperature: 76 K
- Number of Satellites: 27

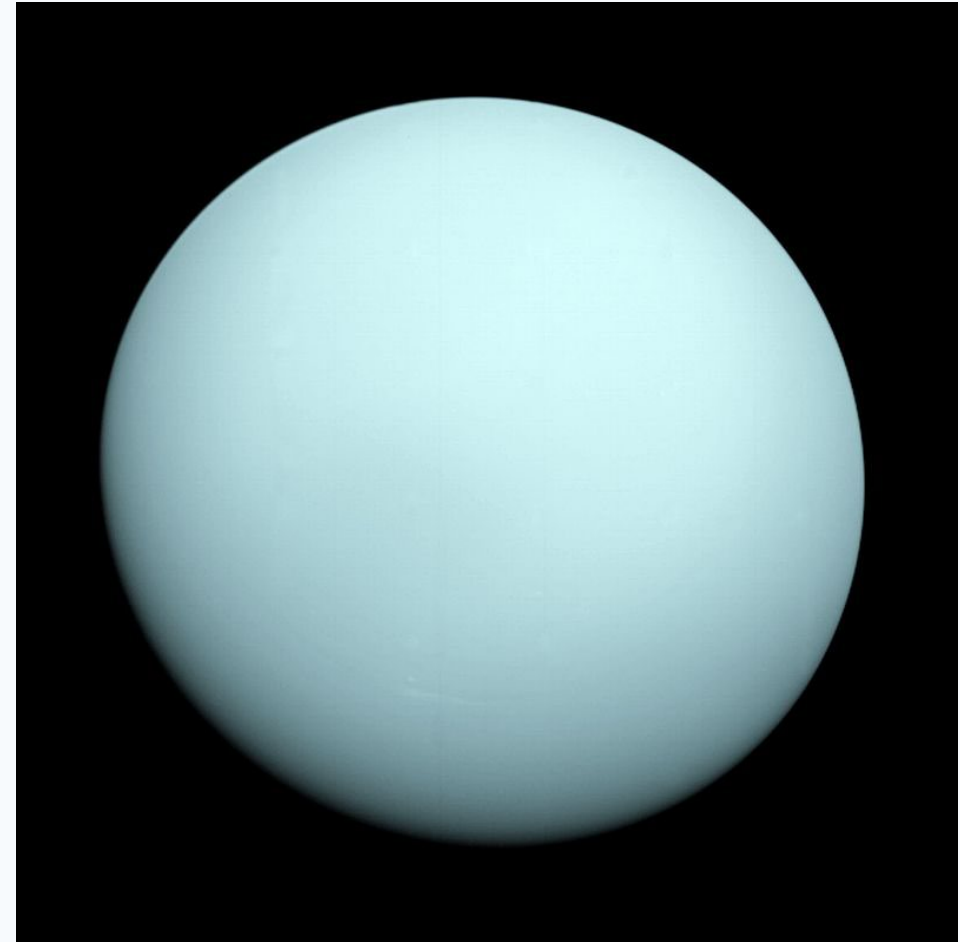


Figure 36. Uranus (Wiki)

Neptune's Properties

- Distance: 4.497×10^9 km (30.1 A.U.)
- Albedo: 0.35
- Size (Diameter): 49,528 km ($4 D_E$)
- Mass: 1.027×10^{26} kg ($17.2 M_E$)
- Density: 1.64 g/cm^3 ($0.297 \rho_E$)
- Length of Year: 164.8 Earth years
- Length of Day: 0.670 Earth days
- Temperature: 72 K
- Number of Satellites: 14

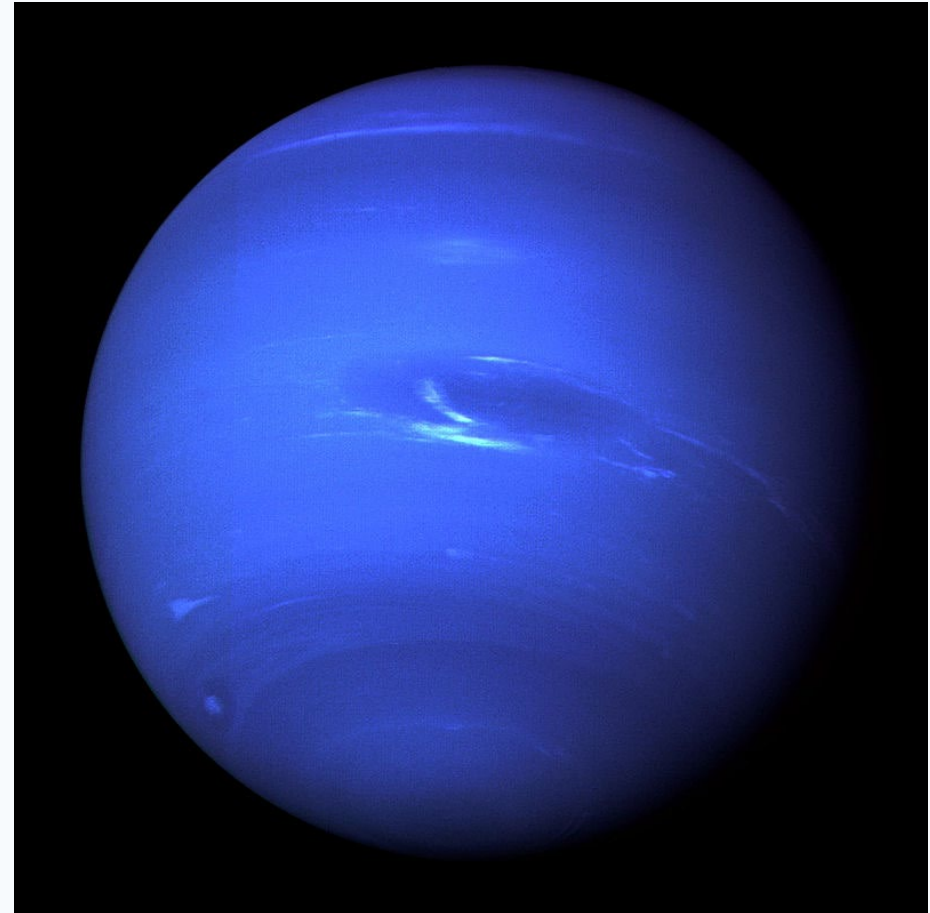


Figure 37. Neptune (Wiki)

Upper Atmospheric Storms

- All the Jovian planets have storms in their active upper atmospheres.
- Belts (high pressure) and Zones (low pressure) move past each other spinning off Storms.
- In the case of Jupiter, the Red Spot was spun off 10,000 years ago. In the case of Saturn, a vortex called the Hexagonal Vortex has formed.
- We have tried to resolve these on Uranus, but a methane haze is making imaging these difficult.



Figure 38. Jupiter's Belts and Zones (Wiki)

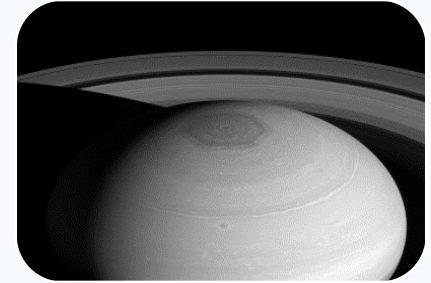


Figure 39. Saturn's Belts and Zones (Wiki)

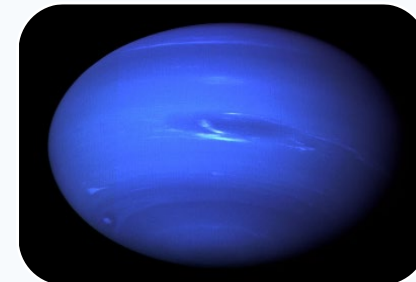


Figure 40. Neptune's Storms (Wiki)

Jovian Planet Rings

- All the Jovian planets have rings.
- The rings are a product of either moons that were broken up due to impacts or charged material caught in the magnetosphere of the planets.
- The objects are guided into the equatorial plane of the planet and kept in place by shepherd moons that gravitationally keep the rings in orbit around the planets.
- Note that Uranus rolls around on its equatorial plane as opposed to the other Jovian planets.

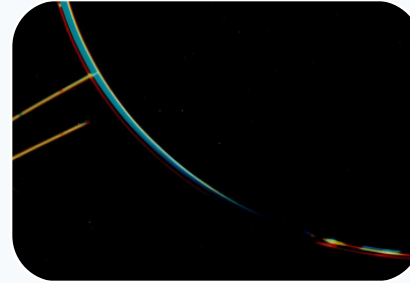


Figure 41. Jupiter's Rings (Wiki)

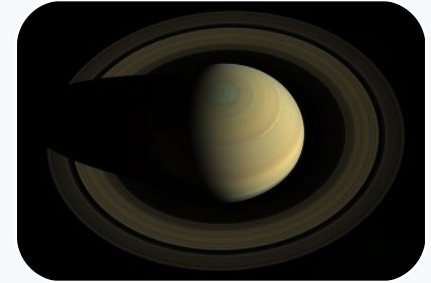


Figure 42. Saturn's Rings (Wiki)

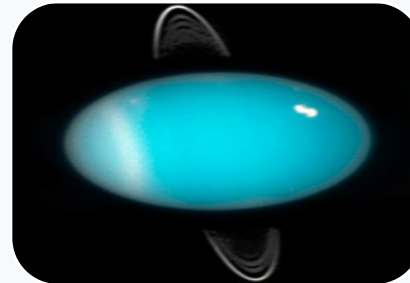


Figure 43. Uranus' Rings (Wiki)

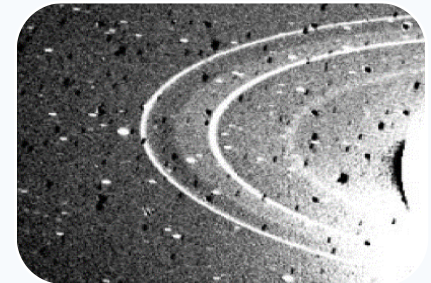
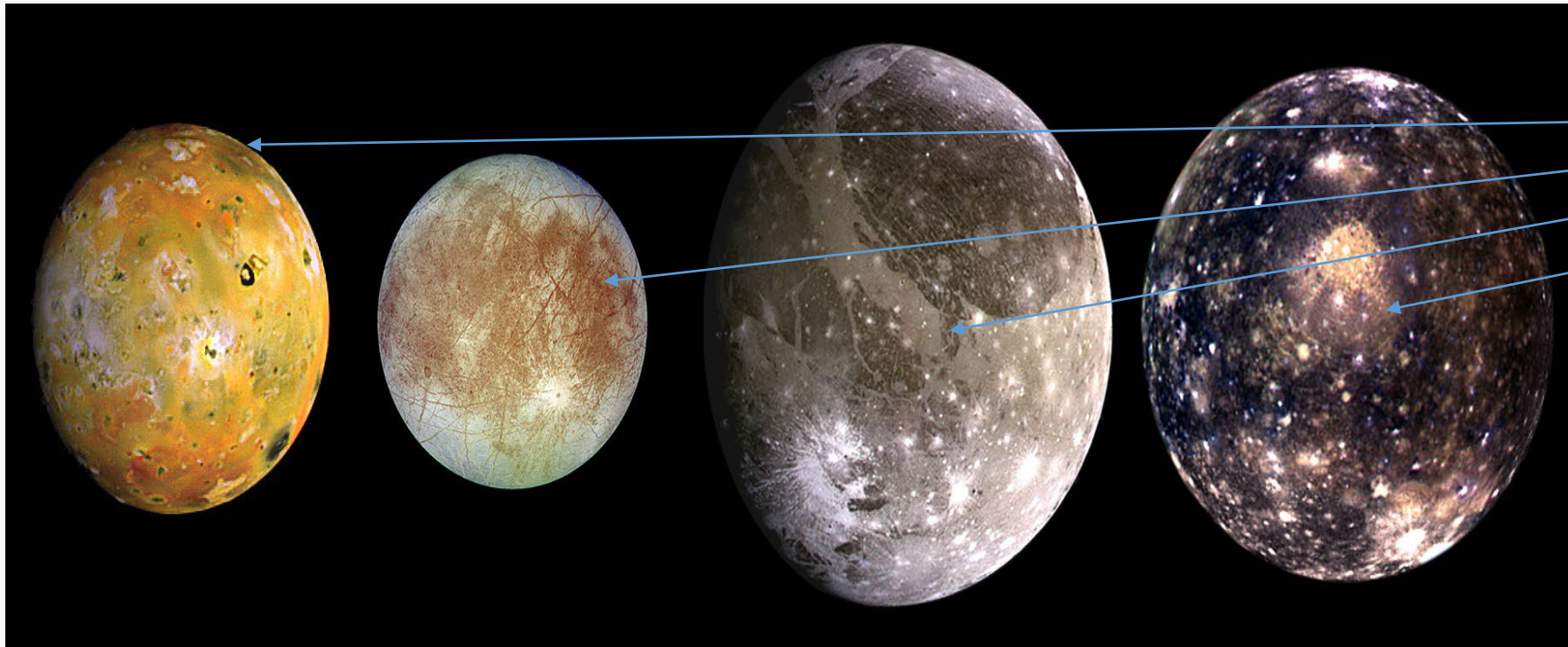


Figure 44. Neptune's Ring (Wiki)

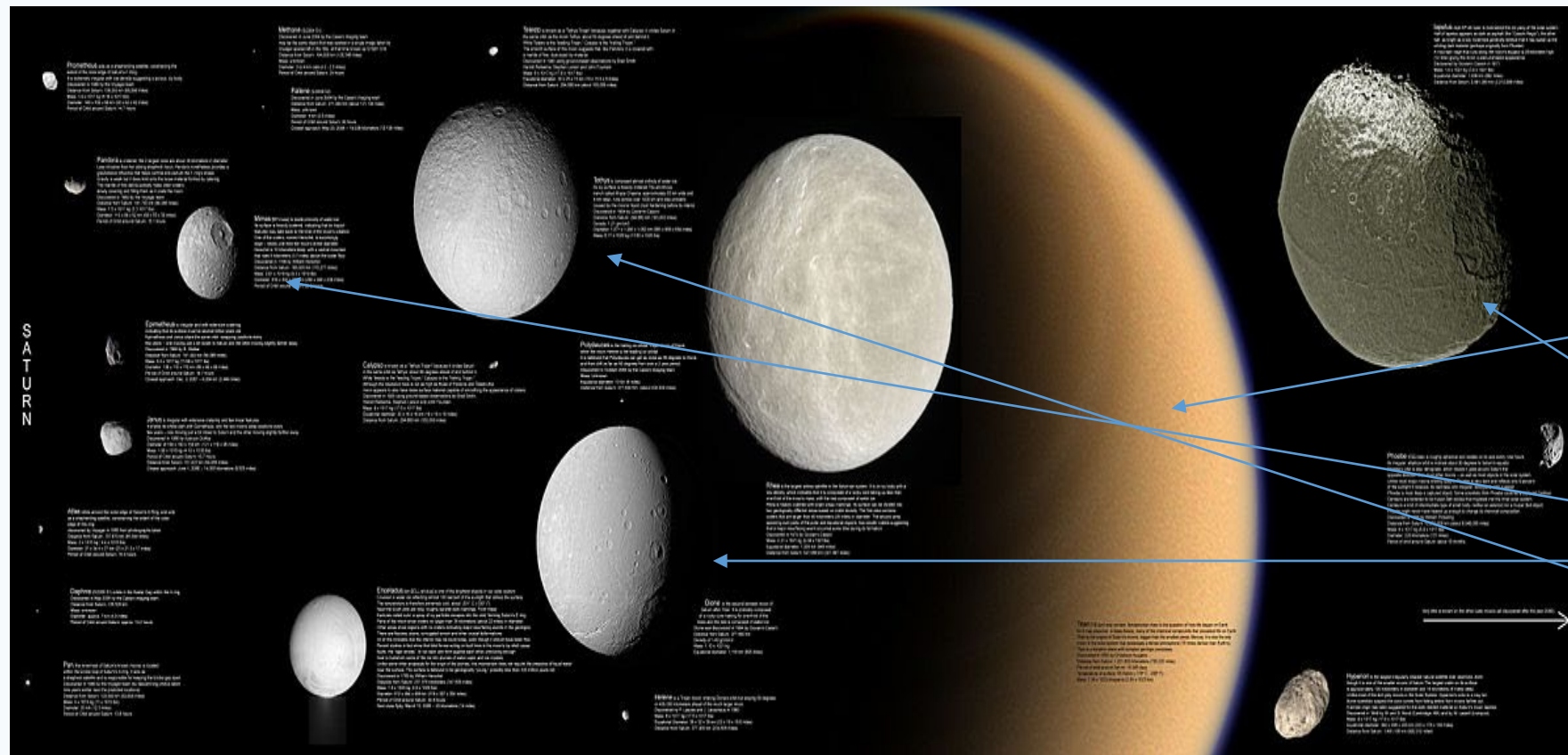
Jupiter's Moons



- The four main moons for Jupiter are Io, Europa, Ganymede, and Calisto.
- Io and Europa are kneaded by the magnetosphere of Jupiter and have fluid surfaces.
- Ganymede and Calisto have been greatly impacted and have many craters.

Figure 45. Jupiter's Moons (Wiki)

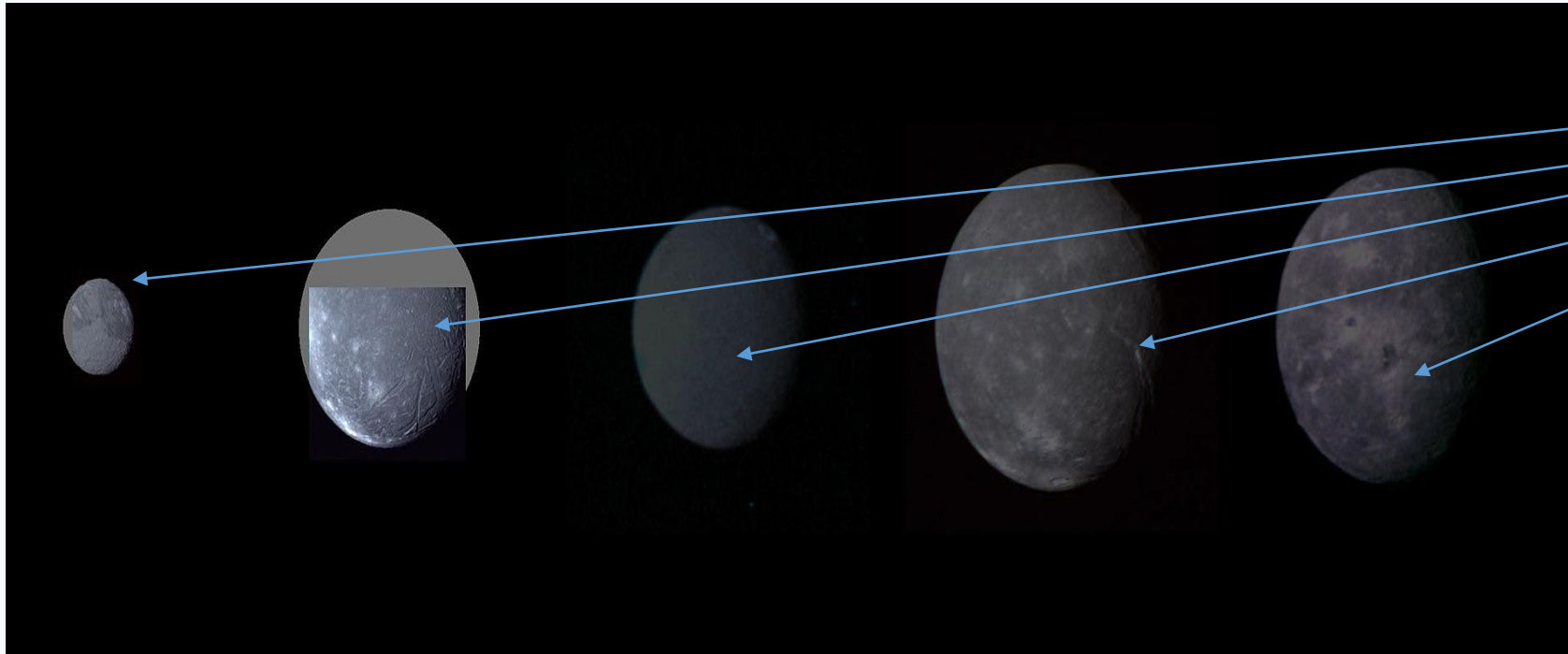
Saturn's Moons



- The main moons of Saturn are Titan, Mimas, Enceladus, Rhea, Tethys, Phoebe, and Dione.
- Titan has an atmosphere of methane very much like the ancient Earth.
- Mimas, Enceladus, Rhea, Dione, Phoebe, and Tethys are icy planets that are kneaded by the magnetosphere of Saturn.

Figure 46. Saturn's Moons (Wiki)

Uranus' Moons



- The five main Uranian moons are Miranda, Ariel, Umbriel, Titania and Oberon.
- Miranda has a complex geology that is thought to be due to the influence of magnetospheres of Uranus.

Figure 47. Uranus' Moons (Wiki)

Neptune's Moons

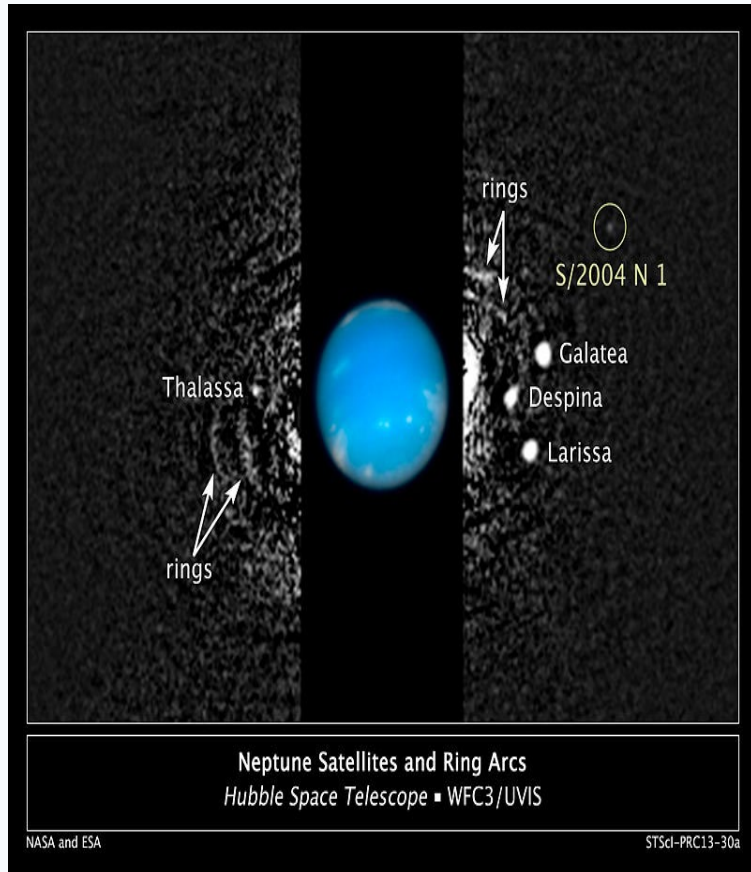


Figure 48. Neptune's Inner Moons (Wiki)

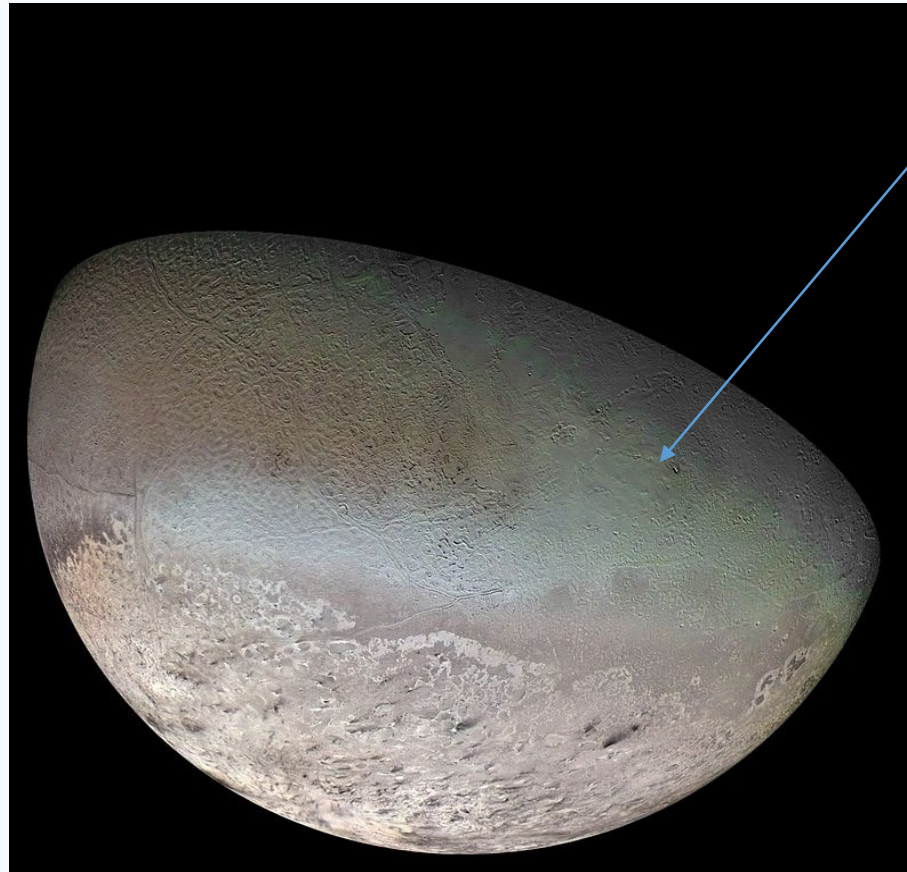


Figure 49. Triton (Wiki)

- The main moon of Neptune is Triton.
- Triton is active due to the magnetosphere of Neptune and has a small atmosphere.
- Most of the moons of the Jovian Planets are captured asteroids or Solar System debris.

What are the Dwarf Planets?

- Dwarf Planets are small rocky, icy bodies that have enough gravity for roundness and do not clear their paths.
- Dwarf planets orbit in belts, clouds, and between planets.
- Dwarf planets can be comprised of many different materials.
- Some dwarf planets have moons.

Dwarf Planets – Ceres, Pluto, and Eris

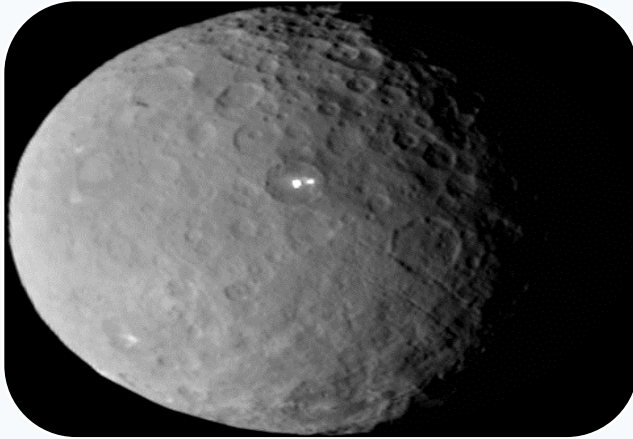


Figure 50. Ceres (NASA/JPL-Caltech/UCLA/MPS/DLR/IDA,2015)



Figure 51. Pluto (NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute,2015)

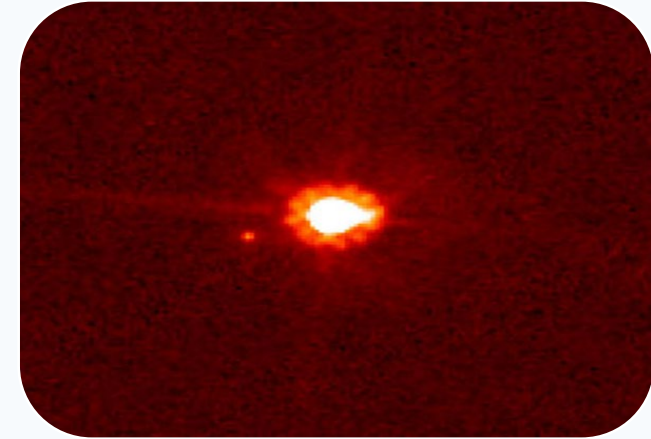
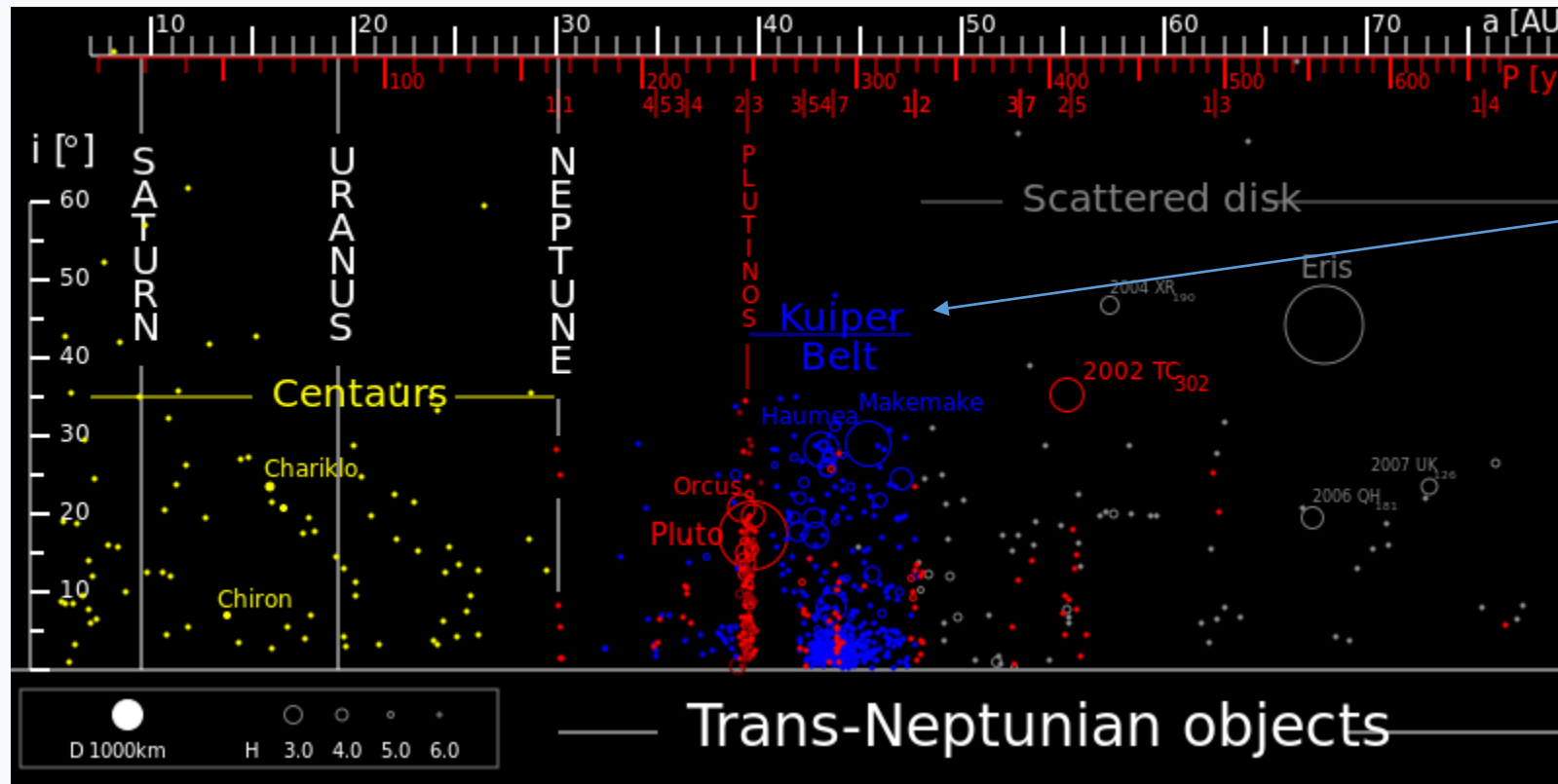


Figure 52. Eris (Wiki)

These are three examples of the dwarf planets. Ceres is inside the asteroid belt between Mars and Jupiter while Pluto and Eris frame the inner and outer Kuiper Belt (a belt near the orbit of Neptune). Some have moons and are planetary systems as much as the major planets.

Outer Solar System Dwarf Planet Orbits



- Most Dwarf planets are outer solar System objects that orbit in a group of icy planetesimals called the Kuiper Belt .
- Ceres is the exception orbiting at 2.5 A.U. in the main asteroid belt.

Figure 53. Orbits of the Outer Solar System Dwarf Planets (Wiki)

Extrasolar Planets

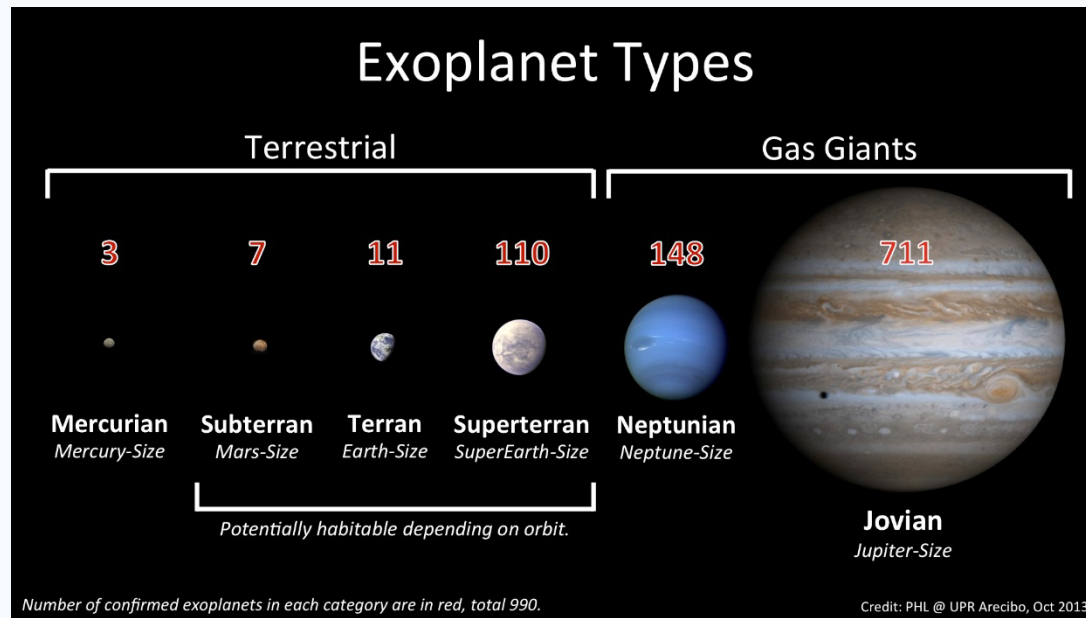


Figure 54. Types of Extrasolar Planets (Mendez, 2015)

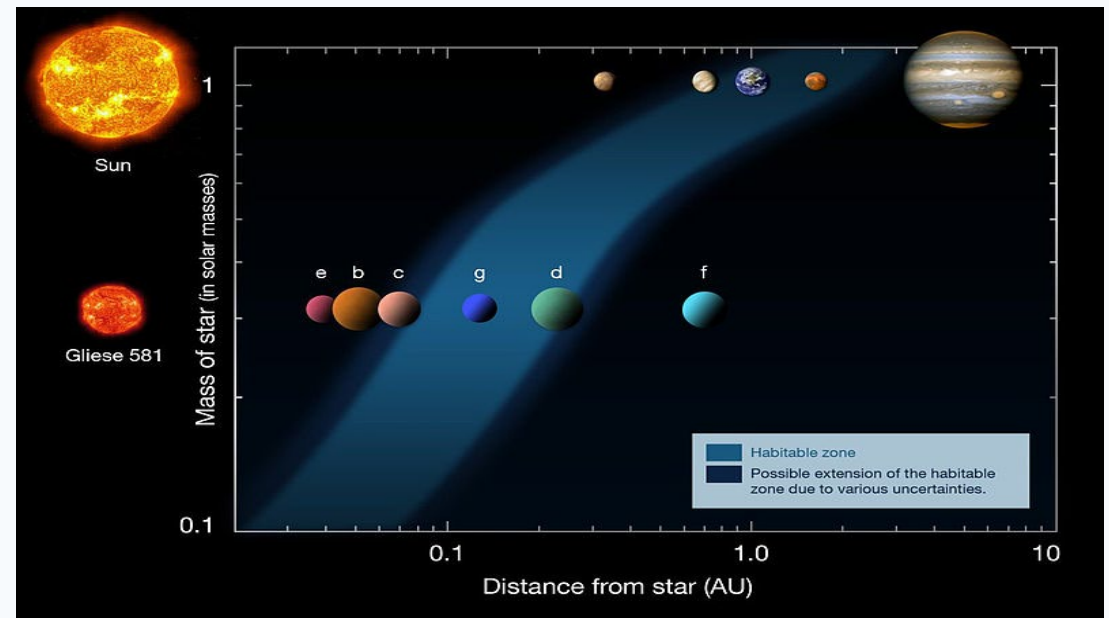


Figure 55. Habitable Zones of Extrasolar Planets (Wiki)

Extrasolar planets are planets found orbiting stars other than our Sun. Extrasolar planets can be either Jovian or Terrestrial. They orbit in different areas than the planets in our Solar System. They are classified by size and orbit.

Number of Extrasolar Planet Candidates

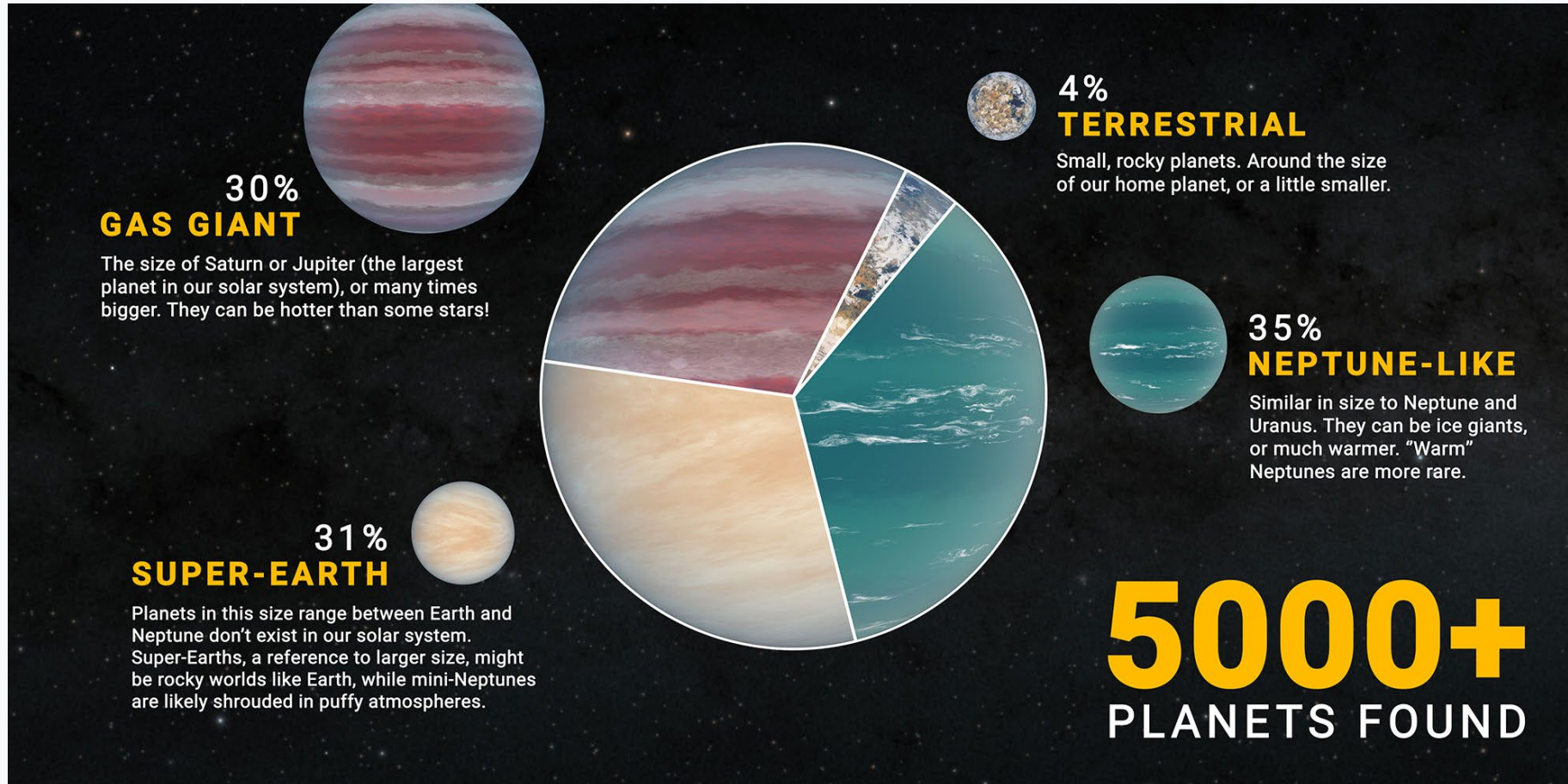


Figure 56. Current Extrasolar Planet Candidates (Brennon, 2022)

Book/Course Image References

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